Inheritance

Announcements

Attributes

Terminology: Attributes, Functions, and Methods

All objects have attributes, which are name-value pairs

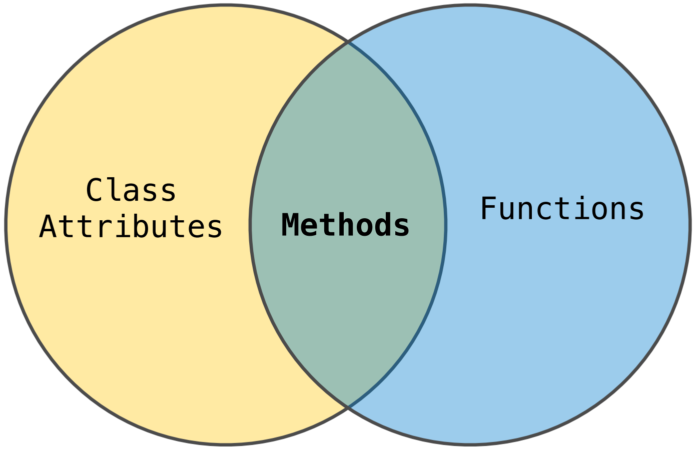
A class is a type (or category) of objects

Classes are objects too, so they have attributes

Instance attribute: attribute of an instance

Class attribute: attribute of the class of an instance

Terminology:



Python object system:

Functions are objects

Bound methods are also objects: a function that has its first parameter "self" already bound to an instance

Dot expressions evaluate to bound methods for class attributes that are functions

<instance>.<method_name>

Looking Up Attributes by Name

`<expression> . <name>`

To evaluate a dot expression:

1. Evaluate the `<expression>` to the left of the dot, which yields the object of the dot expression

2. `<name>` is matched against the instance attributes of that object; if an attribute with that name exists, its value is returned

3. If not, `<name>` is looked up in the class, which yields a class attribute value

4. That value is returned unless it is a function, in which case a bound method is returned instead

Class Attributes

Class attributes are "shared" across all instances of a class because they are attributes of the class, not the instance

```
class Account:

    interest = 0.02   # A class attribute

    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder

    # Additional methods would be defined here
```

```
>>> tom_account = Account('Tom')
>>> jim_account = Account('Jim')
>>> tom_account.interest
0.02
>>> jim_account.interest
0.02
```

The **interest** attribute is ***not*** part of the instance; it's part of the class!

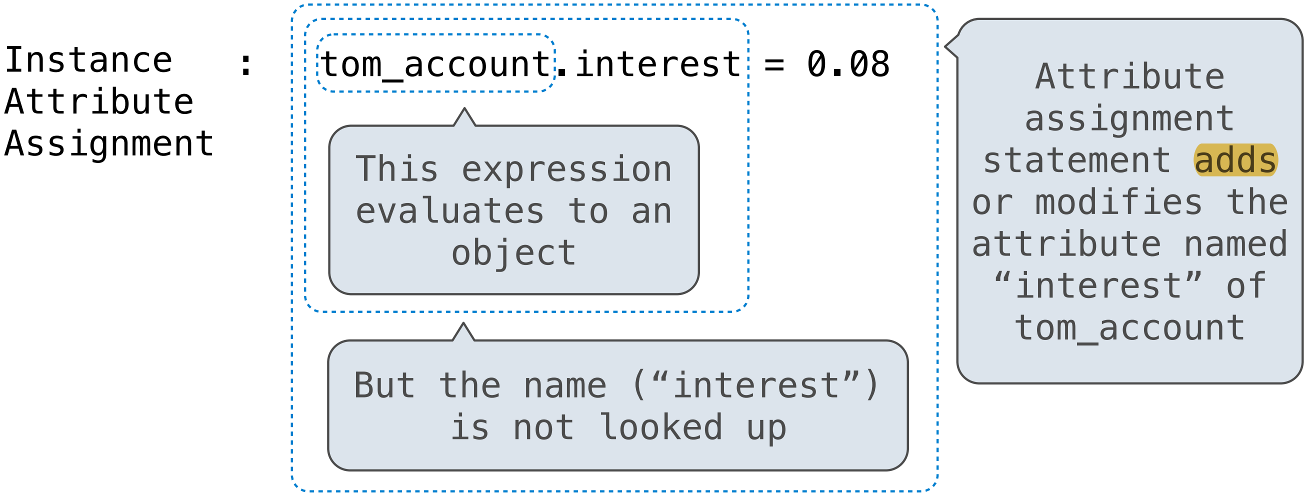
Attribute Assignment

Assignment to Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

- If the object is an instance, then assignment sets an instance attribute
- If the object is a class, then assignment sets a class attribute

```
class Account:
    interest = 0.02
    def __init__(self, holder):
        self.holder = holder
        self.balance = 0
    ...

tom_account = Account('Tom')
```



Instance Attribute Assignment :

```
tom_account.interest = 0.08
```

This expression evaluates to an object

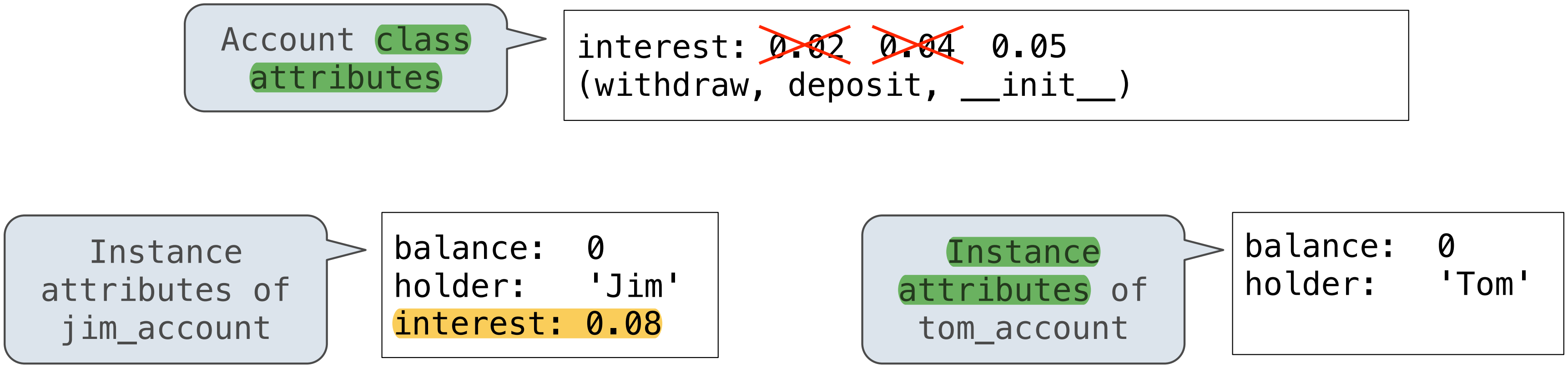
But the name (“interest”) is not looked up

Attribute assignment statement adds or modifies the attribute named “interest” of tom_account

Class Attribute Assignment :

```
Account.interest = 0.04
```

Attribute Assignment Statements



Account class attributes

interest: ~~0.02~~ ~~0.04~~ 0.05
(withdraw, deposit, __init__)

Instance attributes of jim_account

balance: 0
holder: 'Jim'
interest: 0.08

Instance attributes of tom_account

balance: 0
holder: 'Tom'

```
>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
>>> tom_account.interest
0.02
>>> jim_account.interest
0.02
>>> Account.interest = 0.04
>>> tom_account.interest
0.04
>>> jim_account.interest
0.04
```

```
>>> jim_account.interest = 0.08
>>> jim_account.interest
0.08
>>> tom_account.interest
0.04
>>> Account.interest = 0.05
>>> tom_account.interest
0.05
>>> jim_account.interest
0.08
```

Inheritance

Inheritance

Inheritance is a technique for relating classes together

A common use: Two similar classes differ in their degree of specialization

The specialized class may have the same attributes as the general class, along with some special-case behavior

```
class <Name>(<Base Class>):
    <suite>
```

Conceptually, the new subclass inherits attributes of its base class

The subclass may override certain inherited attributes

Using inheritance, we implement a subclass by specifying its differences from the the base class

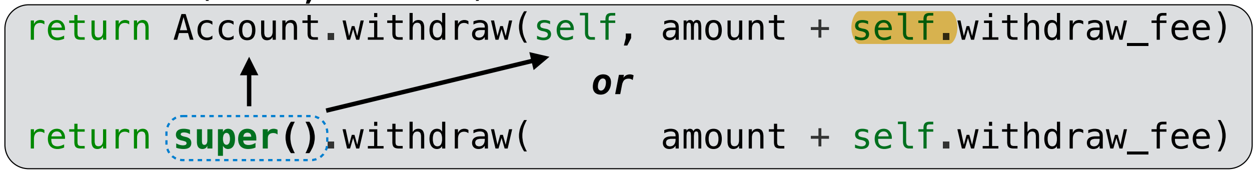
Inheritance Example

A CheckingAccount is a specialized type of Account

```
>>> ch = CheckingAccount('Tom')
>>> ch.interest     # Lower interest rate for checking accounts
0.01
>>> ch.deposit(20)  # Deposits are the same
20
>>> ch.withdraw(5)  # Withdrawals incur a $1 fee
14
```

Most behavior is shared with the base class Account

```
class CheckingAccount(Account):
    """A bank account that charges for withdrawals."""
    withdraw_fee = 1
    interest = 0.01
    def withdraw(self, amount):
```



```
        return Account.withdraw(self, amount + self.withdraw_fee)
                                          or
        return super().withdraw(      amount + self.withdraw_fee)
```

super(). can refer to parent class' function and attributes

Looking Up Attribute Names on Classes

Base class attributes *aren't* copied into subclasses!

To look up a name in a class:

1. If it names an attribute in the class, return the attribute value.

2. Otherwise, look up the name in the base class, if there is one.

```
>>> ch = CheckingAccount('Tom')  # Calls Account.__init__
>>> ch.interest     # Found in CheckingAccount
0.01
>>> ch.deposit(20)  # Found in Account
20
>>> ch.withdraw(5)  # Found in CheckingAccount
14
```

(Demo)

Object-Oriented Design

Designing for Inheritance

Don't repeat yourself; use existing implementations

Attributes that have been overridden are still accessible via class objects

Look up attributes on instances whenever possible

```
class CheckingAccount(Account):
    """A bank account that charges for withdrawals."""
    withdraw_fee = 1
    interest = 0.01
    def withdraw(self, amount):
        return Account.withdraw(self, amount + self.withdraw_fee)
```

Attribute look-up on base class

Preferred to CheckingAccount.withdraw_fee to allow for specialized accounts

Inheritance and Composition

Object-oriented programming shines when we adopt the metaphor

Inheritance is best for representing is-a relationships

- E.g., a checking account is a specific type of account
- So, CheckingAccount inherits from Account

Composition is best for representing has-a relationships

- E.g., a bank has a collection of bank accounts it manages
- So, A bank has a list of accounts as an attribute

(Demo)

Review: Attributes Lookup, Methods, & Inheritance

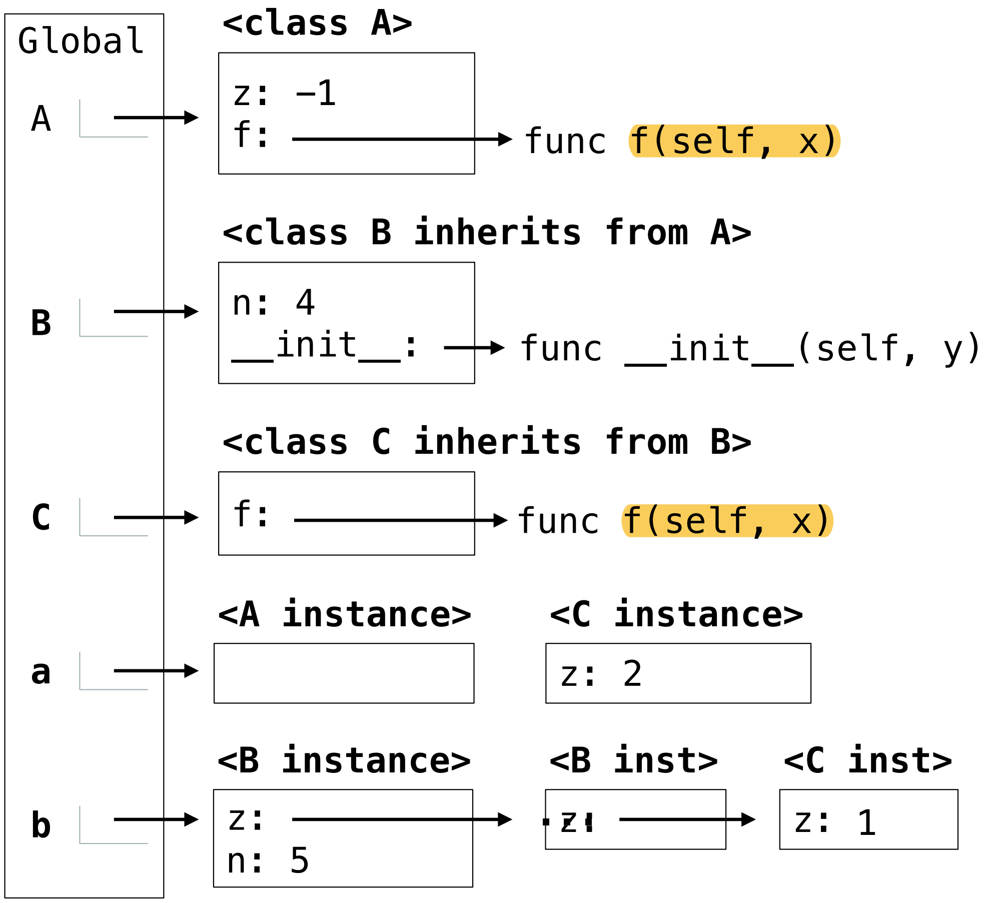
Inheritance and Attribute Lookup

```
class A:
    z = -1
    def f(self, x):
        return B(x-1)

class B(A):
    n = 4
    def __init__(self, y):
        if y:
            self.z = self.f(y)
        else:
            self.z = C(y+1)

class C(B):
    def f(self, x):
        return x


a = A()
b = B(1)
```

```
>>> C(2).n

    4

>>> a.z == C.z

    True

>>> a.z == b.z

    False
```

Which evaluates to an integer?

b.z
b.z.z
▶ b.z.z.z
b.z.z.z.z
None of these



Global
A
B
C
a
b

<class A>
z: -1
f: → func f(self, x)

<class B inherits from A>
n: 4
__init__: → func __init__(self, y)

<class C inherits from B>
f: → func f(self, x)

<A instance>

<C instance>
z: 2

<B instance>
z:
n: 5

<B inst>
z:

<C inst>
z: 1

Environment diagrams for objects aren't required, but can be very helpful!

Multiple Inheritance

Multiple Inheritance

```
class SavingsAccount(Account):
    deposit_fee = 2
    def deposit(self, amount):
        return Account.deposit(self, amount - self.deposit_fee)
```

A class may inherit from multiple base classes in Python

CleverBank marketing executive has an idea:

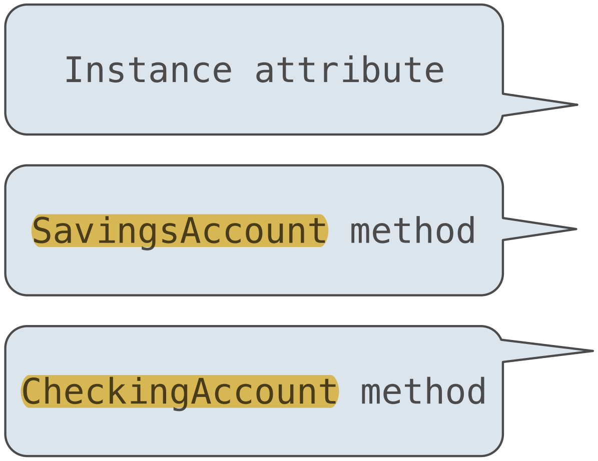
- Low interest rate of 1%
- A $1 fee for withdrawals
- A $2 fee for deposits
- A free dollar when you open your account

```
class AsSeenOnTVAccount(CheckingAccount, SavingsAccount):
    def __init__(self, account_holder):
        self.holder = account_holder
        self.balance = 1                 # A free dollar!
```

Multiple Inheritance

A class may inherit from multiple base classes in Python.

```
class AsSeenOnTVAccount(CheckingAccount, SavingsAccount):
    def __init__(self, account_holder):
        self.holder = account_holder
        self.balance = 1                # A free dollar!
```



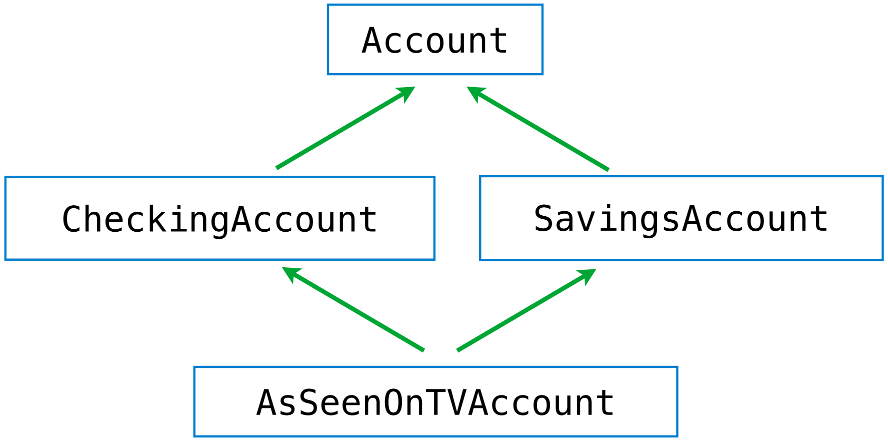
Instance attribute

SavingsAccount method

CheckingAccount method

```
>>> such_a_deal = AsSeenOnTVAccount('John')
>>> such_a_deal.balance
1
>>> such_a_deal.deposit(20)
19
>>> such_a_deal.withdraw(5)
13
```

Resolving Ambiguous Class Attribute Names



Instance attribute

SavingsAccount method

CheckingAccount method

```
>>> such_a_deal = AsSeenOnTVAccount('John')
>>> such_a_deal.balance
1
>>> such_a_deal.deposit(20)
19
>>> such_a_deal.withdraw(5)
13
```